

BBC Microcomputer System

Technical Description

September 1982

PLEASE NOTE THAT
THIS DESCRIPTION
IS SUBJECT TO
ALTERATION
WITHOUT NOTICE



Copyright BBC 1982

The BBC Microcomputer System

PART I - FIRMWARE DESCRIPTION

Section 1 - The BASIC Language Interpreter

This document describes the firmware characteristics of the Microcomputer Unit of the BBC Microcomputer System, as agreed between the British Broadcasting Corporation and Acorn Computers Limited. It forms part of the overall description, firmware and hardware, of the BBC Microcomputer System.

(C) Copyright British Broadcasting Corporation 1982

Listed below are commands, statements and functions which form the "common core".

ABS
AND
ASC
ATN
AUTO
CALL
CHAIN
CHR\$
CLEAR
CLOSE
CLS
COLOUR
COS
DATA
DEF FN
DELETE
DIM
DRAW
ELSE
END
EOF#
EOR
ERL
ERR
EXP
FOR ... TO ... STEP ... NEXT
GET
GET\$
GOTO
GOSUB
IF ... THEN ... ELSE
INKEY
INKEY\$
INPUT
INPUT LINE
INPUT#
INSTR
INT
LEFT\$
LEN
LET
LIST
LN
LOAD
LOG
MID\$
MOD
MOVE
NEW

NEXT
 NOT
 ON ERROR
 ON X GOTO
 ON X GOSUB
 OPENIN
 OPENOUT
 OR
 PI
 POINT
 POS
 PRINT
 PRINT#
 READ
 REM
 RENUMBER
 RESTORE
 RETURN
 RIGHT\$
 RND
 RUN
 SAVE
 SGN
 SIN
 SPC
 SQR
 STEP
 STOP
 STR\$
 STRING\$
 TAB
 TAN
 THEN
 TO
 TRACE
 USR
 VAL
 WIDTH

Extensions.

These extensions should be avoided in simple programs that are intended to be used on a variety of machines.

ACS
ADVAL
ASN
BGET#
BPUT#
CLG
COUNT
DEF PROC
DEG
DIV
ENDPROC
ENVELOPE
EVAL
EXT#
FALSE
GCOL
HIMEM
LISTO
LOCAL
LOMEM
MODE
OLD
OPT
PAGE
PLOT
PTR#
RAD
REPEAT ... UNTIL
REPORT
SOUND
TIME
TOP
TRUE
UNTIL
VDU
VPOS

The BASIC interpreter works through one of four filing systems: the cassette filing system (CFS), the disc filing system (DFS), the network filing system (NFS) or the ROM cartridge filing system. The user can easily move between filing systems and can pass complicated commands direct to the filing system while in BASIC or any other language or environment.

The BASIC interpreter contains an Assembler which accepts standard 6502 mnemonics.

Variables:

Variable names may be of unlimited length and all characters are significant. Variable names must start with a letter. They can only contain the characters A..Z, a..z, 0..9 and underline. Embedded keywords are allowed. Upper and lower case variables of the same name are different.

Keywords are recognised before anything else (e.g. both DEG and ASN in DEGASN are recognised, but neither in ADEGASN). Pseudo variables (PI, LOMEM, HIMEM, PAGE, TIME etc.) act as variables in that if PI is a (pseudo-) variable then it does not affect PILE (or if A is a variable, then AB can be). Note that PI%, PI\$ etc. are not allowed.

The following types of variable are allowed:

A	real numeric
A%	integer numeric
A\$	string

The variables @%..Z% are regarded as special in that they are not cleared by the commands or statements RUN, CHAIN and CLEAR. In addition A%, C%, X% and Y% have special uses in CALL and USR routines and P% has a special meaning in the assembler (it is the program counter). The special variable @% controls numeric print formatting.

The variables @%..Z% are called "static variables", all other variables are called "dynamic variables".

Real variables have a range of approximately +-1E-38 to +-1E38 and numeric functions evaluate to 9 significant figure accuracy. Internally every real number is stored in 40 bits.

Integer variables are stored in 32 bits and have a range of about +-2E9.

String variables may contain up to 255 characters.

All arrays must be dimensioned before use.

All statements can also be used as direct commands.

ABS A function giving the absolute value of its argument.
 X=ABS(deficit)
 length=ABS(X1-X2)
 B=ABSA

ACS A function giving the arc cosine of its argument in radians.
 X=ACS(Y)

ADVAL A function which returns the last known value of ADC channel n.
 X=ADVAL(intensity)
 Y=ADVALN
 Z=ADVAL2

AND The operation of integer bitwise logical AND between two items.
 IF A=2 AND B=3 THEN 110
 A=X AND 3

ASC A function returning the ASCII character value of the first character of the argument string. If the string is null then -1 will be returned.
 X=ASC(A\$)
 X=ASC("HELLO")
 X=ASC"e"
 X=ASC(MID\$(A\$,Z))

ASN A function giving the arc sine of its argument in radians.
 X=ASN(Y)

ATN A function giving the arc tangent of its argument in radians.
 X=ATN(Y)

AUTO A command allowing the user to enter lines without first typing in the number of the line. AUTO mode is left with <escape>. Step size range is 1 to 255.
 AUTO offers line numbers 10, 20, 30
 AUTO 100 starts at 100 with step 10
 AUTO 100,1 starts at 100 with step 1
 AUTO ,2 starts at 10 with step 2

BGET# A function which gets a byte from the file whose channel number is its argument.
E=BGET #N

BPUT# A statement which puts a byte to the file whose channel number is the first argument. The second argument's least significant byte is sent.
BPUT #E,32
BPUT #STAFF_FILE,A/256

CALL A statement to call a piece of machine code. CALL initialises a vector at address hex 0600 in store (actually it's the string input buffer) to contain the number of parameters and pointers to each parameter with an attached type. The processor's A, X, and Y registers and the C carry flag are initialised to the least significant bytes of A%, X% and Y% and the least significant bit of C% respectively, see also USR. Parameter types are:
0: byte (8 bits) e.g. ?A%
4: word (32 bits) e.g. !A% or A%
5: real (40 bits) e.g. A
128: fixed string e.g. \$A% terminated by CHR\$13
129: movable string e.g. A\$
On entry to the subroutine the parameter block contains the following values:
Number of parameters - 1 byte
Parameter address - 2 bytes
Parameter type - 1 byte
Parameter address) repeated as often
Parameter type) as necessary
The value given is the absolute address of the item except for type 129 where it is the address of a parameter block containing start address, maximum length and current length.
CALL MULDIV,A,B,C,D
CALL &FFE3
CALL 12340,A\$,M,J\$

CHAIN A statement which will load and run the program whose name is specified in the argument. All variables except @% to Z% are CLEARed.
CHAIN "GAME1"
CHAIN A\$
CHAIN("jim")

CHR\$ A string function whose value is a string of length 1 containing the ASCII character specified by the least significant byte of the numeric argument.
A\$=CHR\$(72)
B\$=CHR\$12
C\$=CHR\$(A/200)

CLEAR A statement which clears all the dynamically declared variables, including strings. The variables @% to Z% are static: CLEAR will not alter these at all.

CLOSE A statement used to close a sequential file. CLOSE #0 will close all sequential files.
CLOSE #E
CLOSE #0

CLG A statement which is equivalent to PRINT CHR\$16;. It clears the graphics area on the vdu to the current graphics background colour and moves the graphics pointer to 0,0 (bottom left).

CLS A statement which is equivalent to PRINT CHR\$12;. It clears the text area on the vdu to the current text background colour and moves the cursor to 0,0 (top left).

COLOUR A statement which sets the text foreground and background colours of the "soft" displays (modes 0-6). If the argument is >127 the text background colour is affected, otherwise the text foreground colour is affected.
The colours are as follows with the default palette:

0	128	black
1	129	red
2	130	green
3	131	yellow
4	132	blue
5	133	magenta
6	134	cyan
7	135	white
8	136	flashing black-white
9	137	flashing red-cyan
10	138	flashing green-magenta
11	139	flashing yellow-blue
12	140	flashing blue-yellow
13	141	flashing magenta-green
14	142	flashing cyan-red
15	143	flashing white-black

COLOUR 3
COLOUR N+128

- COS** A function giving the cosine of its radian argument.
X=COS(Y)
- COUNT** A function returning the number of characters printed since the last newline (this is not necessarily the same as POS).
A=COUNT
- DATA** A program object which must precede all lists of data for READ. The string values may be quoted or unquoted as for INPUT, the numeric values may include calculation so long as there are no reserved words.
DATA 10,2,HELLO,"THIS IS A COMMA,"
DATA 0,1,2,3.4,jim," print",PRINT
- DEG** A function which converts radians to degrees.
X=DEG(PI/2)
X=DEG(ASN(1))
- DEF** A program object which must precede declaration of a user function FN or a user procedure PROC. If encountered at execution then the rest of the line is ignored so that single line definitions can be put anywhere in the program. Multi line definitions must not be executed; it is recommended that they are placed at the end of the main program text. There is no speed advantage gained in placing them at the start of the program.
DEF FNMEAN
DEF PROCJIM
- DELETE** A command which deletes a group of lines from the program. Both start and end lines of the group will be deleted.
DELETE 10,15 delete 10,11,12,13,14,15
DELETE 0,20 delete up to 20
DELETE 20,32767 delete all lines after 19

DIM A statement which declares arrays. Arrays must be predeclared before use. String arrays may be multi dimensional. After DIM all elements in the array are 0/null. Arrays may not be redimensioned. DIM can also be used to dimension integers to point at an area of memory which the interpreter will not then use. This can be used for positioned strings, data structures and assembler etc. The last item in the example sets A% to an area of memory with bytes A%?0 to A%?67 free for use by the program. The subscript base is 0 so DIM X(12) defines an array of 13 elements.
 DIM A(2),Ab(2,3),A\$(2,3,4),A%(3,4,5,6),A% 67

DIV A binary operation giving the integer quotient of two items.
 X=A DIV B

DRAW Draw a line to the specified position in the current graphics foreground colour. This statement is exactly equivalent to PLOT5.
 DRAW X,Y

ELSE A statement delimiter which behaves as follows:
 When encountered as a delimiter the rest of the line is ignored. If in an IF statement the boolean is false the statements after ELSE will be executed. This makes the following work:
 IF A=B THEN B=C ELSE B=D
 IF A=B THEN B=C:PRINT"WWWW" ELSE B=D:PRINT"QQQQ"
 IF A=B THEN B=C ELSE IF A=C THEN.....
 But this does not work:
 IF A=B THEN B=C:IF C=D THEN B=Q ELSE B=P ELSE B=W
 ELSE also traps exceptions in ON.

END A statement causing the interpreter to return to direct mode. There can be any number (>=0) of END statements anywhere in a program.

ENDPROC A statement denoting the end of a procedure. All LOCAL variables and the dummy arguments are restored at ENDPROC and the program returns to the statement after the calling statement.

ENVELOPE A statement taking 14 parameters which are bytes. The bytes are passed to the Machine Operating System to control the sound generator.
 ENVELOPE 0,1,2,3,4,5,6,7,8,9,10,11,12,13

EOF# A function which will return -1 (TRUE) if the file whose channel number is the argument is at its end.
 IF EOF#B THEN

EOR The operation of bitwise integer logical exclusive-or between two items as 32 bit integers.
 IF A=2 EOR B=3 THEN 110
 X = B EOR 4

ERL A function returning the line number of the line where the last error occurred.
 X=ERL

ERR A function returning the error code number of the last error which occurred.
 X=ERR

EVAL A function which applies the interpreter's expression evaluation program to the characters held in the argument string. An easy way to pass a function into a program from a user input.
 X=EVAL"3"
 X=EVAL("X^Q+Y^P")
 X=EVAL"A\$+B\$"
 X\$=EVAL(A\$)

EXP A function returning e to the power of the argument.
 Y=EXP(Z)

EXT# A function which returns the length, in bytes, of the file whose channel number is the argument. This does not work with cassette files.
 L=EXT#E

FALSE A function returning 0, i.e. false.

FN A reserved word used at the start of all user declared functions. A function may be defined with any number of arguments of any type, and may return (using =) a string or numeric quantity. A function definition is terminated by '=' used in the statement position. The arguments are passed by value.

```
DEF FNMEAN(Q1,Q2,Q3,Q4)=(Q1+Q2+Q3+Q4)/4
DEF FNFACITORIAL(N) IF N<2 THEN =1 ELSE
=FNFACTORIAL(N-1)*N
DEF FNRIGHT2(A$)=RIGHT$(A$,2)
DEF FNREVERSE(A$) LOCALB$,Z%
FOR Z%=1TOLEN(A$):B$=MID$(A$,Z%,1)+B$:NEXT:=B$
```

FOR A statement initialising a FOR NEXT loop. The loop is executed at least once. GOTO inside a loop is in extended range (which means you can't exit the loop with GOTO without leaving it still operative). Any numeric assignable item may be used as the control variable. Integer control variables are three times quicker than real variables at the NEXT statement and are also much faster when indexing an array.

```
FOR TEMPERATURE%=0 TO 9
FOR A(2,3,1)=0 TO 9
FOR X=1 TO 16 STEP 0.3: PRINT X: NEXT X
```

GCOL A statement to set the graphics foreground and background colours and actions. The first value is the action (0 = store, 1= OR, 2= AND, 3= EOR, 4= invert) and the second is the colour, if >127 then background, else foreground (see COLOUR).

```
GCOL 0,RED
GCOL 2,129
```

GET,GET\$ A function and compatible string function that reads the next character from the input stream, usually the keyboard (it waits for the character). See INKEY.

```
N=GET
N$=GET$
```

GOTO A statement which will go to a line with constant number or calculated value. If a calculated value is used, the program should not be RENUMBERed.

```
GOTO 100
GOTO (X*10)
```

GOSUB As GOTO but allows RETURN. Maximum depth is 26 nested GOSUBs.
 GOSUB 400
 GOSUB (4*ANSWER+6)

HIMEM A pseudo-variable which sets and gives the maximum address used by the interpreter. The user is cautioned to use this facility with care!
 HIMEM=HIMEM-40

IF A statement.
 IF length=5 THEN 110
 IF A<C OR A>D GOTO 110
 IF A>C AND C>=D THEN GOTO 110 ELSE PRINT "STRUCTURED BASIC"
 IF A<Q PRINT "I THINK IT IS LESS"
 IF A>Q THEN PRINT "I THINK IT IS GREATER"
 IF A>=Q THEN PRINT "GREATER OR EQUAL":END

INKEY A function and compatible string function that will do a GET/GET\$, waiting for a maximum of n clock ticks (usually 10ms each). If no key is pressed in the time limit INKEY will return -1 and INKEY\$ will return a null string.
 If INKEY has a negative argument then TRUE or FALSE is returned depending on whether the key specified by the argument is depressed at that instant.
 N=INKEY(0)
 N\$=INKEY\$(100)
 IF INKEY(-99) THEN PRINT "Space bar is pressed"

INPUT A statement to input values from the current input stream (usually keyboard).
 INPUT A,B,C,D\$, "WHO ARE YOU",W\$, "NAME"R\$
 If items are not immediately preceded by a printable string (even if null) then a "?" will be printed as a prompt. Items A, B, C, D\$ in the above example can have their answers returned on one to four lines, separate items being separated by commas. Extra items will be ignored. Then WHO ARE YOU? is printed (the question mark comes from the comma) and W\$ is input, then NAME is printed and R\$ is input. The statement INPUT A is exactly equivalent to INPUT A\$:A = VAL(A\$). Leading spaces will be removed from input, but not trailing spaces. Strings in "ed form are taken as they are, with a possible error occurring for a missing closing quote.

INPUT LINE A statement of identical syntax to INPUT which uses a new line for each item to be input. The item input is taken as is, including commas, quotes and leading spaces.

INPUT LINE A\$

INPUT# A statement which reads data in internal format from a file and puts them in the specified variables.

INPUT #E,A,B,C,D\$,E\$,F\$

INSTR A function which returns the position of a sub-string within a string, optionally starting the search at a specified place in the string. If the sub-string is not found 0 is returned.

X=INSTR(A\$,B\$)

Y=INSTR(A\$,B\$,Z%) :REM START SEARCH AT POSITION Z%

INT A function truncating a real number to the lower integer i.e INT(99.8)=99, INT(-12)=-12, INT(-12.1)=-13.

X=INT(Y)

LEFT\$ A string function which returns the left n characters of the string. If there are insufficient characters in the string then all are returned.

A\$=LEFT\$(A\$,2)

A\$=LEFT\$(RIGHT\$(A\$,3),2)

LEN A function which returns the length of the argument string.

X=LEN(A\$)

X=LEN"fred"

X=LENA\$

X=LEN(A\$+B\$)

LET optional assignment statement.

LIST A command which causes lines of the current program to be listed out with the automatic formatting options specified by LISTO.

LIST lists the entire program

LIST ,111 lists up to line 111

LIST 111, lists from line 111 to the end

LIST 111,222 lists lines 111 to 222 inclusive

LIST 100 lists line 100 only

Note that L. is a convenient abbreviation for LIST.

LISTO A command which sets options for formatting a LISTed program. LISTO takes an integer 0 to 7, the bits of which control strings a, b and c:
String a is printed out just after every line number.
String b is printed out n times just after a where n is the level of nested FOR NEXT loops.
String c is printed out m times just after b where m is the level of nested REPEAT UNTIL loops.
The strings are " " (single space), " " (double space), " " (double space).
Note that n and m are set according to the lines actually listed out so far. It is useful to set LISTO 0 when doing a lot of cursor editing, this is the default value.
LISTO 7

LN A function giving the natural logarithm of its argument.
X=LN(Y)

LOAD A command which loads a new program from a file and CLEARs the variables of the old program.
LOAD "PROG1"
LOAD A\$

LOCAL A statement to declare variables for local use inside a function (FN) or procedure (PROC). LOCAL saves the values of its arguments in such a way that they will be restored at = or ENDPROC. See FN for an example.
LOCAL A\$,X,Y%

LOG A function giving the base-10 logarithm of its argument.
X = LOG(Y)

LOMEM A pseudo-variable which controls where in memory the dynamic data structures are to be placed. The default is TOP, the first free address after the end of the program. Changing LOMEM causes loss of all dynamic variables.
LOMEM=LOMEM+100

MID\$ A string function which returns N characters of the string starting from character M. If N is not present or if there are insufficient characters in the string then all from M onwards are returned.
 $C\$ = \text{MID\$}(A\$, M, N)$
 $C\$ = \text{MID\$}(A\$, Z)$

MOD A binary operation giving the signed remainder of the integer division. MOD is defined such that $A \text{ MOD } B = A - (A \text{ DIV } B) * B$
 $X = A \text{ MOD } B$

MODE A statement which will select the specified vdu screen mode (0-7). The space provided by a 20K screen changing to a 1K screen is automatically recovered by MODE. MODE cannot be used inside a PROC or FN, unless on a second processor.
The display modes are as follows:

0	640x256 2-colour graphics and 80x32 text	(20K)
1	320x256 4-colour graphics and 40x32 text	(20K)
2	160x256 16-colour graphics and 20x32 text	(20K)
3	80x25 2-colour text	(16K)
4	320x256 2-colour graphics and 40x32 text	(10K)
5	160x256 4-colour graphics and 20x32 text	(10K)
6	40x25 2-colour text	(8K)
7	40x25 teletext mode	(1K)

$\text{MODE } 0$
 $\text{MODE } A$

MOVE A statement which moves the graphics pointer to the specified position. It is exactly equivalent to PLOT4.
 $\text{MOVE } X, Y$

NEW A command which initialises the interpreter for a new program to be typed in. The old program may be recovered with the OLD command provided no variables have been created and no lines have been typed in.

NEXT The statement delimiting FOR NEXT loops. NEXT takes an optional control variable; if present then FOR NEXT loops may be 'popped' in an attempt to match to the correct FOR statement.
 NEXT
 $\text{NEXT } J, K$

NOT This is a high priority unary operator (the same priority as unary -).
 IF NOT(RATE>5 AND TIME<100) THEN

OLD A command which undoes the effect of NEW provided no new lines have been typed in, and no variables have been created.

ON A statement controlling a multi-way switch or error trapping. The values in the list are skipped without calculation but it will get confused by ASC", " appearing.
 ON A+2 GOTO 100,200,300,120,300 ELSE PRINT"Illegal"
 ON B-46 GOSUB 100,200,(C/200) ELSE PRINT"What?"
 ON ERROR PRINT"Suicide":END
 ON ERROR GOTO 100
 ON ERROR OFF: REM sets back normal error handler

OPENIN A function which returns the channel number of the file. The file is opened for input and updating. If it does not exist 0 is returned. OPENIN is an abbreviation of OPEN FOR INPUT. With the CFS input only is allowed, with the DFS or NFS input and output are allowed (random access).
 X=OPENIN"jim"
 X=OPENINA\$
 X=OPENIN(A\$)
 X=OPENIN("FILE1")
 Example of reading in N(10) and N\$(10), a top ten array:
 A=OPENIN"TOPTEN"
 IFA=0 PRINT"No TOPTEN data file":END
 FORZ=1TO10:INPUT#A,N(Z),N\$(Z):NEXT:CLOSE#A
 Example of writing out the top ten array:
 A=OPENOUT"TOPTEN"
 FORZ=1TO10:PRINT#A,N(Z),N\$(Z):NEXT:CLOSE#A
 Example of reading the bytes in TOPTEN backwards:
 A=OPENIN"TOPTEN"
 FORZ=EXT#A-1TO0STEP-1:PTR#A=Z:PRINTBGET#A,:NEXT:CLOSE#A

OPENOUT A function which creates a file and returns its channel number. If a file of that name is already present it is first deleted. OPENOUT is an abbreviation of OPEN FOR OUTPUT.
 X=OPENOUT(A\$)
 X=OPENOUT("DATAFILE")

OPT An assembler pseudo operation controlling the method of assembly. OPT is followed by an expression with the following meanings:-

Value	Action
0	assembler errors suppressed; no listing
1	assembler errors suppressed; listing
2	assembler errors occur; no listing
3	assembler errors occur; listing

Where the possible assembler errors are branch out of range and unknown label. The default OPT is 3.

OR The operation of bitwise integer logical OR between two items:

```
IF A=2 OR B=3 THEN 110
X=B OR 4
```

PAGE A pseudo-variable controlling the starting address of the current text area. With care several programs can be left around in RAM memory without the need for saving them. PAGE is always an integer multiple of 256.

```
PAGE=25*256
PAGE=PAGE+512
```

PI A function returning 3.14159265.
X=PI

PLOT A statement controlling most of the graphics. The first argument controls whether points or lines will be drawn, how pixels are put on the screen, and whether the coordinates (the other arguments) are relative or absolute.

Currently assigned values:

Bits zero and one

00 No change in memory while plotting (e.g. MOVE)

01 Plot in graphics foreground colour

10 Plot INVERT

11 Plot in graphics background colour

Bit 2

0 Plot coordinates are relative

1 Plot coordinates are absolute

Bits 3 to 6

(a) Bit 6 clear: lines and curves

Bit 3 clear - plot both endpoints

set - plot first endpoint twice

Bit 4 clear - plot continuous

set - plot dotted

Bit 5 clear - plot line

set - plot curve ***FUTURE EXPANSION***

(b) Bit 6 set: plot special objects
Modes &40 to &47 plot point
Modes &50 to &57 plot and fill triangle
Example PLOT&41,X,Y plots a point at X,Y
PLOT K,X,Y

POINT A function returning the logical colour of the point on the screen or -1 if off screen.
PRINT POINT(100,100)

POS A function returning the horizontal position of the cursor on the screen; left hand column is 0. See COUNT for printer compatible version.
X=POS

PRINT A statement. PRINT has a pair of local variables PRINTS and PRINTF (print size and print flag) which can be set or unset by various delimiters. The variable @% controls numeric print format and spacing of field output by PRINT, the bytes of @% from lsb upwards will be referred to as f1, f2, f3 and f4. For a description of the action of f4 see STR\$. f3 selects the numeric format mode:

- 0 general (G) mode
- 1 exponent (E) mode
- 2 fixed (F) mode

The initial mode is G mode.

f2 controls the number of digits in a mode. If it is out of range then 9 is assumed. In G mode it specifies the maximum number of digits to be printed between 1 and 9. In E mode it specifies the exact number of digits to be printed between 1 and 9. In F mode it specifies the number of digits to follow the decimal point, between 0 and 9.

E mode will print an optional - sign, one digit, a decimal point, f2-1 digits, an E and an exponent field in 3 characters, padded with trailing spaces if necessary. The G mode will print integral values as integers, numbers in the range 0.1 to 1 as 0.1 etc, numbers less than .1 or greater than 1E f2 with an exponent of as few characters as possible. F mode will print numbers with f2 digits after the "." unless the total number would then have more than nine digits in which case G mode is used.

Examples (all shown right justified)

number	G2	G9	F2	E2
.1	0.1	0.1	0.10	1.0E-1
.01	1E-2	1E-2	0.01	1.0E-2
.001	1E-3	1E-3	0.00	1.0E-3
.005	5E-3	5E-3	0.01	5.0E-3
1	1	1	1.00	1.0E0
10	10	10	10.00	1.0E1
100	1E2	100	100.00	1.0E2

Initially, and every time a ",", is encountered, PRINTS is set to fl. Initially and every time either ", " or ";" is encountered, PRINTF is set to false. When a "~" is encountered PRINTF is set to true. When a "^" is encountered a new line is generated. When a " " is encountered, then 0 or more spaces are output so that the current print position is a multiple of fl. When a ";" is encountered PRINTS is set to zero. When a numeric value is to be printed, it is printed in hexadecimal notation if PRINTF is true, and in decimal notation otherwise. A numeric value is printed right justified in a field of size PRINTS; if there is not enough space in the field (e.g. PRINTS is 0) then it is printed in the minimum number of characters possible (trailing spaces in E mode are printed). A string value is printed with no extra characters at all. If the last non-space character in the PRINT statement is not a ";" then a new line will be generated.

Examples	Result
@%=&00090A	
PRINT 1,2	1 2
PRINT10,200	10 200
PRINT10;200	10200
PRINT"Answer ";A	Answer 42
PRINT"Answer "A	Answer 42
PRINT"Answer ",A	Answer 42
PRINT"Hello","Hello"	Hello Hello
PRINT"Hello";"Hello"	HelloHello
PRINT1^20	1 20

PRINT#

A statement which writes the internal form of a value out to a sequential file.

PRINT#E,A,B,C,D\$,E\$,F\$

PROC A reserved word used at the start of all user declared procedures. Any number of parameters, including zero, may be passed; they are passed by value. The procedure does not have to be declared before it is called.

```

INPUT"Number of discs "F
PROCHANOI(F,1,2,3)
END
DEF PROCHANOI(A,B,C,D) IFA=0 ENDPROC
PROCHANOI(A-1,B,D,C)
PRINT"Move disk ";A" from pile ";B" to pile ";C
PROCHANOI(A-1,D,C,B)
ENDPROC

```

PTR# A pair of statement and function which allow the programmer to select the next byte to be transferred to/from a file and thus enables random access. This does not work with cassette files.

```

PTR#A=PTR#A-20

```

RAD A function which converts degrees to radians.

```

X=RAD(Y)
X=SINRAD(90)

```

READ A statement which will assign to variables values read from the DATA statements in the program. Strings must be enclosed in double quotes if they have leading spaces or contain commas.

```

READ C,D,A$

```

REM A statement that causes the rest of the line to be ignored.

RENUMBER A command which will renumber the lines and correct the cross references inside a program. Options as for AUTO. RENUMBER produces messages when a cross reference fails.

```

RENUMBER
RENUMBER 1000
RENUMBER 1000,5

```

REPEAT A statement which is the starting point of a REPEAT...UNTIL loop. These loops may be nested up to a maximum depth of 20. Leaving a loop with GOTO brings you into Extended Range, the loop can be reentered. UNTIL TRUE will 'pop' the stack. A single REPEAT may have more than one UNTIL.

```

REPEAT A=A+1:UNTILA>B
REPEAT
X=X+10
PRINT "What do you think of it so far?"
UNTIL X>45

```

REPORT A statement which prints out a newline followed by the error string associated with the last error which occurred.

RESTORE RESTORE can be used at any time in a program to set the place where DATA comes from. The optional parameter for RESTORE can specify a calculated line number.

```

RESTORE
RESTORE 100
RESTORE (10*A+20)

```

RETURN A statement causing a RETURN to the statement after the most recent GOSUB statement.

RIGHT\$ A string function which returns the right n characters of the string. If there are insufficient characters in the string then all are returned.

```

A$=RIGHT$(A$,2)
A$=RIGHT$(LEFT$(A$,3),2)

```

RND A function with optional parameter. RND(1) returns a real number in the range 0.0 to .99999999. RND returns a random integer 0 - &FFFFFFF. RND(n) returns an integer in the range 1 to n. If n is negative the pseudo random sequence generator is set to a number based on n and n is returned. If n is 0 the last random number is returned in RND(1) form.

```

X=RND(1)
X%=RND
N=RND(6)

```

RUN Start execution of the program. RUN is a statement and so programs can reexecute themselves. All variables except @% to Z% are CLEARED by RUN.

SAVE A statement which saves the current program area to a file.
 SAVE "FRED"
 SAVE A\$

SGN A function returning -1 for negative argument, 0 for 0 argument and +1 for positive argument.
 X=SGN(Y)

SIN A function giving the sine of its radian argument.
 X=SIN(Y)

SOUND A statement taking 4 parameters, considered by BASIC to be 16 bit words. These parameters are channel, envelope/amplitude, frequency (pitch) and duration. The values are passed straight to the Machine Operating System. If the second parameter is in the range -15 to 0 then it selects a constant amplitude (-15 is loudest); if it is positive it selects an envelope.
 SOUND 1,-15,MIDDLE_C,QUAVER

SPC A function which can only be used in PRINT or INPUT. SPC outputs n MOD 256 spaces where n is the argument.
 PRINT DATE;SPC(6);SALARY

SQR A function returning the square root of its argument.
 X=SQR(Y)

STEP Part of the FOR statement, this optional section specifies step sizes other than 1.

STOP Syntactically identical to END, STOP also prints a message to the effect that the program has stopped.

STR\$ A string function which returns the string form of the numeric argument as it would have been printed. The msb of @%, if non zero, lets STR\$ use the current @% description for printing numbers, if zero (the initial value) then G9 format (see PRINT) is used.
 A\$=STR\$(PI)

TRUE A function having a true value (-1).

UNTIL A part of the REPEAT ... UNTIL structure.

USR A function allowing machine code to return a value directly for things which do not require the expense of CALL. USR calls the machine code subroutine whose address is its argument with the processor's A, X and Y registers and the C carry flag initialised as in CALL and returns a 32 bit integer composed of PYXA msb to lsb.
 X=USR(LIFT_DOWN)

VAL A function which converts a character string representing a number into numeric form. Unless the argument is a unary signed constant VAL returns 0.
 X=VAL(A\$)

VDU A statement which takes a list of numeric arguments and sends them to OSWRCH. A word can be sent if the value is followed by a ";". The bytes sent DO NOT contribute to the value of COUNT, but may well change POS and VPOS (e.g. VDU 30 would home the cursor).
 VDU28,0,31,32,0:REM define window
 VDU27,0;0;1280;1024;

VPOS A function returning the vertical cursor position. The top of the screen is line 0.
 X=VPOS

WIDTH A statement controlling output overall field width. The initial value is WIDTH 0 when the interpreter will not attempt to control the overall field width. WIDTH n will cause the interpreter to force a newline after n MOD 256 characters have been printed.
 WIDTH 60

Operators and special symbols.

- ! A unary and binary operator giving 32 bit indirection.
- ? A unary and binary operator giving 8 bit indirection.
- " A delimiting character in strings. Strings always have an even number of " in them. " may be introduced into a string by the escape convention "\".
- # Indicates "immediate" operation in assembler; precedes reference to a file channel number (and is not optional).
- \$ A character indicating that the object has something to do with a string. The syntax \$<expression> may be used to position a string anywhere in memory, overriding the interpreter's space allocation. As a suffix on a variable name it indicates a string variable.
- % A suffix on a variable name indicating an integer variable.
- & Precedes hexadecimal constants e.g. &EF
- ^ A character which causes newlines in PRINT or INPUT.
- () Objects in parentheses have highest priority.
- = "Becomes" for LET statement and FOR, "result is" for FN, relation of equal to on integers, reals and strings.
- Unary negation and binary subtraction on integers and reals.
- * Binary multiplication on integers and reals; statement indicating operating system command.
- : Multi statement line statement delimiter.
- ; Suppresses forthcoming action in PRINT or INPUT.
- + Unary plus and binary addition on integers and reals; concatenation between strings.
- , Delimiter in lists.
- . Decimal point in real constants; abbreviation symbol on keyword entry; introduce label in assembler.
- < Relation of less than on integers, reals and strings.
- > Relation of greater than on integers, reals and strings.
- / Binary division on integers and reals.

- <= Relation of less than or equal on integers, reals and strings.
- >= Relation of greater than or equal on integers, reals and strings.
- <> Relation of not equal on integers, reals and strings.
- [] Delimiters for assembler statements. Statements between these delimiters will need to be assembled twice in order to resolve any forward references. The pseudo operation OPT (initially 3) controls errors and listing.
 Example:


```

10 oswrch=&FFF4
20 FORZ=1TO3STEP2:P%=TOP+1000
30 [ opt Z : .start lda # ASC"! "
40 ldx # 40
50 .loop jsr oswrch
60 dex:bne loop
70 rts:] NEXT
80 CALL start
90 END

```
- ^ Binary operation of exponentiation between integers and reals.
- ~ A character in the start of a print field indicating that the item is to be printed in hexadecimal.

Expression Priority:

- (1) variables, functions () ! ? &, unary + - NOT
- (2) ^
- (3) * / MOD DIV
- (4) + -
- (5) = <> <= >= > <
- (6) AND
- (7) EOR OR

Examples of use of the priority

```

IF A=2 AND B=3 THEN          IF ((A=2)AND(B=3)) THEN
A=?C AND &FFF              A=((?C)AND(&FFF))
IF A=1 OR C=2 AND B=3 THEN  IF ((A=1)OR((C=2)AND(B=3))) THEN
IF NOT(A=1 AND B=2) THEN   IF (NOT((A=1)AND(B=2))) THEN

```

Characters permitted in variable names

```

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o p q r s t u v w x y z
0 1 2 3 4 5 6 7 8 9 _

```


The BBC Microcomputer System

PART II - HARDWARE DESCRIPTION

Section 1 - The Microcomputer Unit

This document describes the hardware characteristics of the Microcomputer Unit of the BBC Microcomputer System, as agreed between the British Broadcasting Corporation and Acorn Computers Limited. It forms part of the overall description, firmware and hardware, of the BBC Microcomputer System.

(C) Copyright British Broadcasting Corporation 1982.

THE BBC MICROCOMPUTER SYSTEM

HARDWARE DESCRIPTION

Section 1 - The Microcomputer Unit

GENERAL

The machine is designed to the highest engineering standards and all component parts are used within the manufacturers' recommended limits. Particular care has been taken with printed-circuit layout and supply decoupling. Unused gate inputs are not left open-circuit.

All items in this specification apply to the Models A and B BBC Microcomputer unless specifically indicated otherwise. With the sole exception of the Econet interface, integrated circuit sockets are fitted in all unequipped positions.

CASE

Dimensions: 412mm wide by 350 mm deep by 70mm high approx.

Material: Injection moulded thermoplastic.

External appearance: Cream coloured case with black keyboard escutcheon.

The case is designed to enclose the printed circuit board and mains power supply and to provide a rigid support for the keyboard. It is sufficiently strong to withstand rough handling in transit, particularly with regard to the mounting of heavy items such as the power supplier.

The case is of two-part construction, the lower shell supporting the keyboard PCB, the main PCB and the power supply. Electrical connection between the main PCB and the keyboard PCB is by flexible ribbon cable. Precautions have been taken to prevent malfunction resulting from electrical coupling between ribbon cable conductors.

All printed circuit boards are copper-on-fibreglass and have screen-printed component legends. The main logic board is through-hole-plated and has a solder resist.

Apertures are provided for expansion connectors plus sufficient ventilation slots to allow for continuous use at a local ambient temperature of 35C without subjecting the internal components or case material to a temperature in excess of their rated maximum (with all expansion options fitted).

The two parts of the case are secured together by four metal screws. The case is provided with non-slip non-scratch feet commensurate with its use in a domestic environment (on polished furniture etc.).

ELECTRICAL SAFETY

The unit meets the appropriate BEAB, BSI and European standards and is so marked. It is constructed in accordance with BSI Class 1 requirements, i.e. all exposed metalwork is connected to earth via the earth lead of the 3-core mains cable. All points which could be at mains potential when power is applied are inaccessible to the "standard finger".

MECHANICAL SAFETY

There are no sharp edges or corners which could cause damage to person or clothing when the covers are in place.

KEYBOARD

The keyboard is in standard QWERTY format using a pitch between keys and between rows of 0.75", with a conventional row-stagger of 0.375" and 0.1875". There are four rows of alphanumeric keys plus a space-bar and an additional top row of ten software-definable keys, 73 keys in all. The two SHIFT keys and the RETURN key are at least 1.5 times the normal key size and the space bar is approximately 5.5" long with a mechanism to allow it to be pressed with equal ease anywhere along its length. The keyboard is fixed at a standard operating angle.

There are four cursor-control keys at the right-hand end of the main keyboard; LEFT, UP, RIGHT and DOWN. The keyboard can generate all ASCII codes (0/0 to 7/15) by using the SHIFT and CTRL keys in conjunction with the other keys. The space bar and zero key are not affected by depressing the SHIFT key.

The keys have positive action with a total travel of approximately 0.2", the keypress being detected at approximately 50% total travel. The keyboard has two-key rollover on all keys except SHIFT, CTRL, SHIFT LOCK and CAPS LOCK. It is possible under software control to determine whether a key is held depressed or has been released.

A RESET (or BREAK) key is provided on the main keyboard but can be disabled by cutting a link on the keyboard printed circuit board.

The keys are two-shot mouldings; both pound sign and number symbol (hash) are included (the detailed keyboard layout showing legends and codes produced is attached).

The keyboard is software scanned but this is made transparent to the user, and processing overhead minimised, by interrupting the processor and scanning the keyboard only when a key is pressed.

POWER SUPPLY

The power supply accepts a mains input of between 220 and 260 volts rms at a frequency of 47-63 Hz. The total consumption does not exceed 50VA. The unit is rated to power the machine continuously with all on-board expansions fitted. The power supply will withstand an overload indefinitely and will protect itself from damage through overheating.

There are no exposed mains terminals within the case; the three core mains lead provided has a moulded-on plug fitted with a 3 amp fuse.

COMPOSITE VIDEO OUTPUT

A 1v pk-pk (75 ohms) monochrome composite video output is provided on a 75 ohm BNC socket accessible at the rear of the machine. The TV standard is 625-lines, 50-field interlaced, with a field-sync pulse consisting of a single broad pulse of 128us duration. An internal modification allows chrominance information to be added to this output.

UHF OUTPUT

The UHF output is from an Astec modulator fixed tuned to approximately channel 36, for feeding to a domestic TV set. This is negative modulated by a PAL-coded composite video signal. The signal characteristics are as defined in the previous section with the addition of chrominance information at a subcarrier frequency of 4.43361875 MHz +/- 100Hz over the temperature range 5-35 C (ambient). A 2m long flying lead is provided for connection to the TV receiver, terminated by a standard Belling Lee plug. The other end of the lead is fitted with a Phono plug for connection to the modulator through an aperture in the rear panel of the computer.

RGB OUTPUTS (Model B only)

Four outputs at TTL levels are provided, being red, green & blue video signals and a composite (mixed) sync pulse signal. These are suitable for driving a high input impedance RGB monitor. The TV standard is as previously defined. The connector for these outputs is not fitted in the Model A machine.

AUDIO CASSETTE INTERFACE

A cassette modem is incorporated to allow storage of programs and data on a standard audio cassette recorder, mono or stereo. The format is asynchronous serial data with one start bit (space), eight data bits (LSB first) and one stop bit (mark) per byte at one of two alternative speeds, 300 baud and 1200 baud. In the low-speed mode a MARK bit (logic 1) is encoded as 8 cycles of 2400Hz tone and a SPACE (logic 0) as 4 cycles of 1200Hz tone. In high-speed mode a MARK is 2 cycles of 2400Hz tone and a SPACE is 1 cycle of 1200Hz tone. It is possible to switch between low-speed (CUTS) mode and high-speed mode under software control, without internal modification.

The demodulator is insensitive to input level variations of up to +6dB or -12dB and recovers the UAR/T clock from the tape in order to track short and long-term speed variations. It caters for an instantaneous speed error of at least 10% WITHOUT relying on the inherent insensitivity to speed of asynchronous data, i.e. bit-centre sampling is maintained. The demodulator is insensitive to phase of the played-back signal.

Input and output levels are standard DIN. Appropriate low-pass filtering is incorporated in the output to avoid subjecting the cassette recorder to high-frequency components which could cause overloading or other forms of distortion. The input circuitry incorporates band-pass filtering to reduce the sensitivity of the demodulator to high and low frequency noise, hum etc.

The cassette connector is a seven-pin DIN socket wired so that if a stereo recorder is used both channels are recorded but replay is from the left channel only.

A relay is included in the basic machine which can be used to switch the cassette recorder tape-transport motor on and off. This relay is adequately rated to switch loads which are highly inductive. The relay is driven by the operating system so as to allow the easy storage and recall of cassette data files. Connections to the relay contacts are brought to pins 6 & 7 of the DIN connector.

RS423 SERIAL INTERFACE (Model B only)

When the cassette interface is not in use, the serial port is available to provide a bi-directional RS423 (+/-5v) interface for driving a serial printer etc. Provision is made on the main PCB to include the necessary interface i.c.'s but neither these nor the connector are fitted in the Model A machine. Baud rate is selectable under software control to any value from the group 75, 150, 300, 1200, 2400, 4800, 9600 or 19200 bauds; the speeds are accurate to within 0.2%. A simple handshaking input is provided which inhibits the serial output when negative and enables it when positive (RS423 levels). It is also possible for the user to provide his own printer driver software to implement, for example, form feed or handshake using the reverse serial channel.

PARALLEL PRINTER INTERFACE (Model B only)

A parallel printer output to Centronics specifications is provided in the Model B Microcomputer, using a 6522 input/output device plus buffers.

It is possible for the user to intercept the normal driver software for the parallel printer so as to add special features such as software form-feed.

FLOPPY DISC INTERFACE (Option)

Provision is made on the main PCB to fit a floppy disc controller plus data separator and buffer devices to allow interfacing to one or two 5.25" or 8" floppy disc drives. Neither these devices nor the connector are fitted in the Model A machine. The connector alone is fitted in the standard Model B machine. The disc connector is a 34-way type to SA400 specification but all control signals are present to allow an SA800 specification interface to be implemented by means of an adaptor cable. A link on the main PCB selects the appropriate data rate, i.e. 125 kbits/sec for mini-floppy and 250 kbits/sec for 8" floppy. The hardware is capable of supporting 8" discs to the IBM 3740 specification, but the standard Disc Operating System, present in an additional ROM not fitted in the Model A or Model B machines, will support mini-floppy discs only.

ANALOGUE INPUTS (Model B only)

Provision is made on the main PCB to fit a four-channel twelve bit analogue to digital converter device to which external X-Y joystick controls can be connected. The ADC and connector are not fitted in the Model A machine. The connector is a 15-way D-type which also includes the light-pen input (q.v.).

ECONET INTERFACE (Option)

Provision is made on the main PCB to fit a 6854 I/O device plus buffering to implement an Acorn version 3.0 Econet interface. These devices are not fitted in the Model A or the Model B machines.

PROCESSOR BUS INTERFACE ("TUBE") (Model B only)

Un-buffered address, data and control signals are available on a 40-way connector to provide a high-speed interface to an external language processor (e.g. the Z80 CP/M option). The interface is suitable only for this purpose and uses a short length of ribbon cable as interconnection between the two units. The connector is not fitted in the Model A machine.

1 MHz BUS INTERFACE (Model B only)

A buffered processor bus interface is provided for connection to other items such as the teletext receiver/data grabber. Interconnection between the main machine and the extensions is by means of ribbon cable having alternate ground conductors, allowing a cable length of at least 30 cm. The connector is not fitted in the Model A machine.

SOUND GENERATOR

A loudspeaker is fitted in the Model A and Model B machines as standard. This is fed from a three-voice sound-generator device capable of producing tones, music and noise under software control.

USER INPUT/OUTPUT (Model B only)

A TTL-compatible 8-bit port plus 2 control bits is provided in the Model B machine for user input/output.

LIGHT-PEN INPUT (Model B only)

An input is provided which allows the connection of a simple light-pen, fed to the 6845 CRT controller. This input uses the same connector as the analogue inputs. The light pen itself is not supplied.

VDU SCREEN FORMATS

There are 8 selectable display formats as follows (RAM requirements in bytes are shown in brackets):

- | | | |
|----|--|-------|
| 0. | 640*256 2-colour graphics & 80*32 text. | (20K) |
| 1. | 320*256 4-colour graphics & 40*32 text. | (20K) |
| 2. | 160*256 16-colour graphics and 20*32 text. | (20K) |
| 3. | 80*25 2-colour text | (16K) |
| 4. | 320*256 2-colour graphics & 40*32 text. | (10K) |
| 5. | 160*256 4-colour graphics & 20*32 text. | (10K) |
| 6. | 40*25 2-colour text. | (8K) |
| 7. | 40*25 teletext-compatible display. | (1K) |

The alphanumeric characters displayed in modes 0 to 6 are generated in high-resolution graphics with the "character generator" being part of the operating system ROM. These characters are on an 8*8 matrix (with one-line descenders). In display modes 3 and 6 there are forced gaps between character rows and therefore continuous vertical lines (on forms etc.) are not possible. The character set is ASCII with the exception that code

6/0 gives a pound sign.

In modes 0 to 6 the "colours" are selectable from a palette of 16 effects being black, red, green, yellow, blue, magenta, cyan, white and the same eight colours automatically flashing.

Mode 7 uses a teletext character generator to provide a full teletext/prestel format display including character rounding, double-height, 8 display colours, 8 background colours, non-contiguous graphics, held graphics, flash etc.

The circuitry to generate all these display modes is present in the Model A machine, but it is not possible to use display modes 0 to 3 unless the 16K RAM expansion option is fitted.

All display modes use nominally 40us active horizontal display period and 256 lines per field active vertical period, i.e. 77% and 89% respectively of the nominal TV display area.

Processor access to the display refresh RAM is totally transparent and the display is therefore completely glitch-free.

CENTRAL PROCESSOR

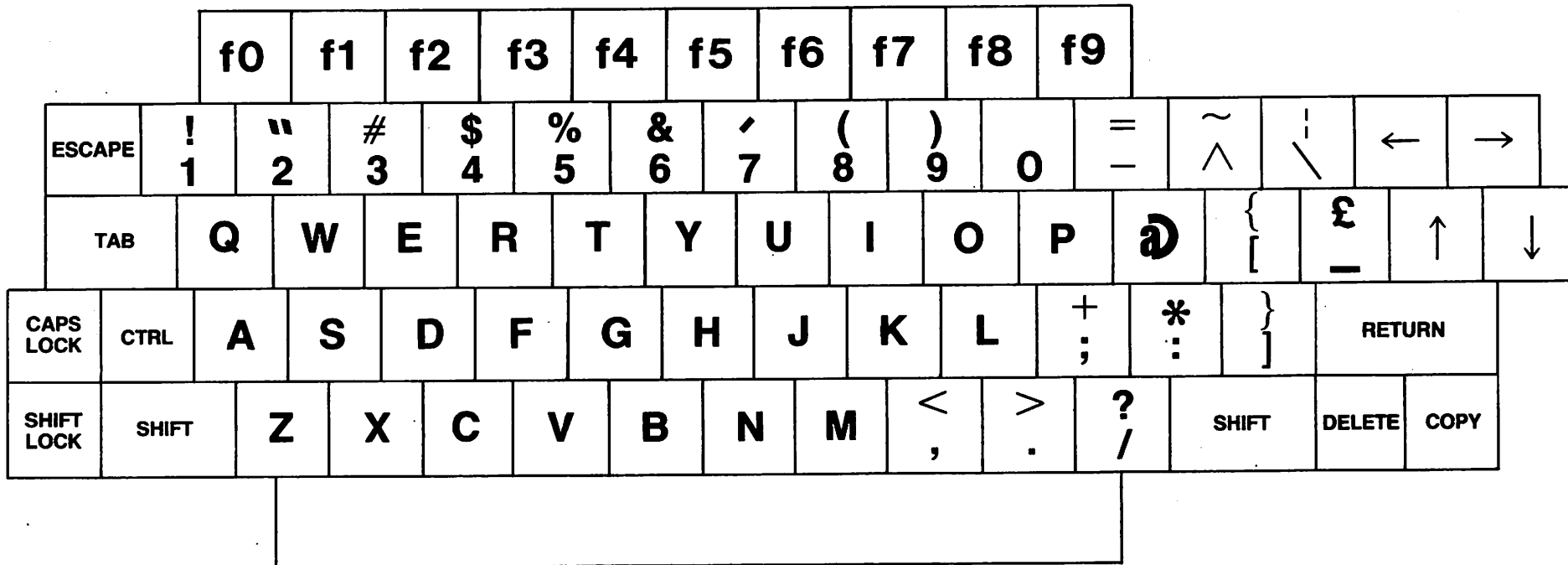
The CPU is a 6502A running at a 2MHz clock rate except when accessing some input-output devices, when the effective clock frequency is reduced to 1MHz.

MEMORY

The Model A machine is equipped with 16 Kbytes dynamic random-access-memory (5v type), 16 Kbytes operating system ROM (character generator, input/output handlers, cassette operating system etc.) and 16 Kbytes language ROM (BASIC interpreter). The RAM is capable of expansion to 32 Kbytes and the ROM to 80 Kbytes (being another 16 Kbyte language ROM - e.g. Pascal - plus up to 32 Kbytes of ROM/EPROM containing applications software etc. Only one of the language ROMs, or the ROM/EPROM, can be enabled at any given time under software control).

RADIO FREQUENCY INTERFERENCE

The level of R.F. radiation from the machine has been minimised.



BBC MICROCOMPUTER KEYBOARD LAYOUT